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ABSTRACT

The consistently inferior performance of economically disadvantaged children led to this study designed to investigate how cognitive development changes with age and how it is affected by previous life experience. Classification behavior and inferential thinking were the main concerns of the study. The measurement instrument was the Matrix Test, a device that requires the child to select a picture to complete a row of pictures on the basis of the relationship established by the other pictures. The 44 items on the test can be seen as falling into one of four classes: Perceptual Matching, Class Membership, One-Way Classification, or Two-Way Classification. The subjects were 160 black lower class children (40 each from kindergarten and grades 1 through 3) and a similar group of white middle class children for comparison. Only a child's selection responses were recorded; no measure was made of the thought processes behind them. The measurable results showed no differences based on sex or the abstract-representational character of the stimuli. However, consistent differences between advantaged and disadvantaged children were found to be significant for all four classes of items. (MH)

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Classification and Inferential Thinking in Children of Varying Age and Social Class[1]

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The widespread academic failure of disadvantaged children has served to underline the need for a reappraisal of educational methods and a detailed assessment of these children's cognitive skills. Prompted by the latter concern, the present study addressed itself to two broad questions: (1) How does cognitive development change with age -- with increasing physical maturation and life experience, and (2) how is cognitive development affected by variations in the quality of previous life experience; in this instance, how does variation in social class and ethnicity, with all its attendant consequences for the early intellectual and emotional experiences of the child, influence the course of intellectual growth?[2]

Analysis of the cognitive functioning of disadvantaged children proceeds most effectively on a comparative basis; the absence of absolute forms of measurement requires a relativisitic approach involving a familiar frame of reference, i.e., the middle-class child. Despite the invidious racial comparisons which a comparative study of middle-class white and disadvantaged black children may provoke, the use of a white middle-class group as a standard of comparison is dictated by the fact that most available information regarding the cognitive development of children is based on the observation and study of white middle-class children.

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2. This study was conducted under the auspices of the Head Start Evaluation and Research Center of Bank Street College, which is supported by OEO.

The focus of this work was on classification behavior and inferential thinking. The measurement of these attributes was achieved by the use of the Matrix Test, a method devised in our Research Division.[3] Based upon a format used by Inhelder and Piaget (1964) to study classification behavior in young children, the Matrix Test consists mainly of newly constructed items combined with a few devised by Inhelder and Piaget. The test also resembles Raven's Progressive Matrices Test, but its format and content are more suited for use with young children -- it includes representational as well as abstract items, it requires a less abstract attitude, and it presents items individually, on separate cards (8" x 15"), rather than in a booklet.

Each of the 44 items of the test presents a matrix of 2 x 2 or 2 x 3 squares. One square is empty in each case; the others contain two-dimensional geometric figures or pictures of familiar objects which bear some relationship to each other on the basis of their appearance, content or spatial position in the matrix (e.g., circles or vehicles). The subject is expected to find the figure or picture for the empty square on the basis of the relationship established by the figures in the other remaining squares. He makes his choice from among four figures or pictures presented alongside the matrix. The subject is merely asked to point to the figure that he belives to belong to the empty square. This format has the advantage of simplicity of administration and ease of communicating the essential requirements of the task. Unlike other procedures, in which the intricacy of the procedure may elude the grasp of the young child (as in conventional sorting tasks, for example, in which the child may fail to understand the request to "choose the objects which are alike" or

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3. The valuable contributions of Harvey Asch in the construction of the Matrix Test, and of Susan Laurenco and John Kaufman in the data gathering are gratefully acknowledged.

"which belong together"), the conspicuousness of the empty square in the Matrix Test almost invariably communicates even to the youngest child what he is supposed to do. Further, after the task is presented initially, the test can proceed without any verbal interchange between examiner and child. For the young child who feels assaulted by the speech of adults, or who does not feel sufficiently comfortable with a strange adult to talk with him, a test that minimizes the need for verbal interaction provides him with an opportunity to function with a minimum of disturbance and interference.

Content of the Matrix Test

The test is made up of 44 items. Although the items were originally constructed to present one-way and two-way classification problems, four different classes of items may be distinguished in all. These four classes of items have been called: Perceptual Matching, Class Membership, One-Way Classification, Two-Way Classification.

The three Perceptual Matching items present the easiest task. They present a 2 x 2 matrix in which the figures in all three occupied squares are identical. Both abstract and representational figures are included among the three Perceptual Matching items. The task simply requires the child to find the figure among the four alternatives that is identical to those in the three occupied squares of the matrix; no abstraction or complex inference is entailed.

The 18 Class Membership items each present a 2 x 2 matrix in which the three occupied squares contain different figures that have a common feature. In some of the items containing abstract figures, color or form is the common feature; in a few others, the relationship of a combination of variables, such as size and color, constitutes the common element. Most of the Class Membership items present representations of objects that may be subsumed under some common category of classification. These items vary in their degree of abstractness

of the unifying category of classification.

The 11 One-Way Classification items present 2 x 3 (as well as some 2 x 2) matrices of abstract or representational figures in which all the members of the vertical arrays (columns) or horizontal arrays (rows) are the same. Thus the identity of the missing figure is given by its column or row membership.

The 12 Two-Way Classification items present matrices (all but two are 2 x 3) in which the row and column membership, in combination, determine the nature of the missing figure. Thus, whereas all the members of the same row or column (as the case may be) of the One-Way Classification items are identical, in the Two-Way Classification, no two squares contain identical figures.

Although countless variations in the sequence of presentation of all 44 items are possible, thus far the Matrix Test has been administered in a uniform order. The blocks of items are presented in toto, in the same order in which these four groupings have been presented here. The child is not told of the transitions in task requirement of the blocks of items presented to him. In addition, there has been no attempt to probe the child's response to any given item. Variations in the sequence and mode of presentation of the items, and experimentation with a form of inquiry, are currently being contemplated.

Method

Children in kindergarten and grades 1, 2 and 3 of two public schools were given the Matrix Test. School A is located in a middle-class neighborhood and its children come from white, middle-class families predominantly. Virtually all the children attending School B are from lower-class, black families. In each school, 40 children (20 boys and 20 girls) were tested in kindergarten and each of the first three grades. Two examiners, one male, the other female, both white, each tested half the children (10 boys and 10 girls) from each of the grade levels in each of the schools. In those grades in which there was homogeneous grouping,

the sample was drawn in equal numbers from the upper, middle and lower levels of ability. In all, 320 children were tested.

Results

As indicated previously, the data were analyzed to show differences in cognitive behavior as a function of age and social class-ethnicity. It should be noted that no striking differences in performance between the sexes, or as a function of the abstract-representational character of the stimuli were found.

The three Perceptual Matching items posed relatively little difficulty for even the youngest of the four age groups studied. Performance on the first two items, the first of which presented a geometric figure -- a red circle in three squares of the matrix -- and the second a picture of a pocket watch, established that all the children understood the simple demands of the Matrix Test -- to point to the figure among the alternatives that belonged in the vacant square. The third item, a line drawing of a cow, was more difficult because the alternatives included other four-legged animals -- a dog and a horse. It is of interest that about one fifth of the disadvantaged group at each age level responded incorrectly to this third item, whereas the item ceased to present any problem to the middle-class groups beyond the kindergarten level.

Although there is insufficient time to report the children's performance on each of the 18 Class Membership items, the data obtained from the first two items are of sufficient interest to warrant presentation in Figure 1. It has already been noted that Class Membership items were the first that did not present identical stimuli in every cell of the matrix. The first such item called for an abstraction on the basis of form since all the figures in the matrix were triangles of different colors. It may be observed from Figure 1 that virtually the entire sample, particularly those in the first grade or above, solved the problem correctly. The common attribute in the second Class Membership item was

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color. In this instance, failure was more widespread, particularly in the disadvantaged group. Among the disadvantaged groups, there was no appreciable change in performance on this item as a function of age. Thus the greatest disparity in performance on this item between the middle-class and disadvantaged children was in the oldest age group.

With the exception of two other items, both of which called for the recognition of a relation between the size and color of a set of bars presented in each matrix cell -- a problem which was clearly too difficult for even the oldest groups in the sample -- the remaining Class Membership items involved representational or pictorial stimuli. In those instances in which the category under which each picture in the cell could be subsumed was a familiar one to children, almost all the children were successful. For example, when all the occupied cells of the matrix contained <u>birds</u>, or <u>fruit</u>, or <u>vehicles</u>, or <u>men</u>, or <u>girls</u>, even the youngest groups, irrespective of their social-class background, for the most part responded successfully. It was not that the children had to know the <u>name</u> of the common attribute for them to perform correctly, but rather that the common attribute among the objects had to be highly salient. For example, it is doubtful that many of the children had the word "vehicle" available to them, but the vehicular quality of the objects portrayed in the cells was so compelling that it was a rare child who failed this item. In another item, the objects portrayed in the matrix had in common the fact that they could all be found in the street -- they included a stop sign, a fire hydrant and a mailbox. The correct answer, a traffic light, was almost always chosen from among the four alternatives that otherwise consisted of objects customarily found indoors. In this instance, it may not have been the verbal mediation but the high frequency of previous association with these perceptual stimuli that helped solve the problem. Similarly, an item that contained objects usually found inside a

house, and another that involved objects used in conjunction with babies, were responded to successfully despite the fact that the verbal mediation required for solution was rather awkward. At this point, it should be reiterated that the children were not asked to give the basis for their pointing response, so that this discussion regarding the availability of verbal mediators is conjectural.

The more difficult Class Membership items included some which required definitions of categories that may not have been known to the children. For example, a portion of the younger children, mostly disadvantaged, were not able to match a dog presented among alternative four-legged animals with a matrix which presented varieties of dogs in each cell. Still more difficult, particularly for the disadvantaged children, was the item which presented various four-legged animals in the matrix, but included a fish as the only animal among the alternatives from which the child could choose. Apparently, many of these children did not know that a fish can be included in the category of animal. A complicating factor in this instance was the inclusion of a doghouse among the alternatives and a dog among the animals presented in the matrix. The connection between these two was too compelling for many of the children to withstand.

In a pair of the Class Membership items which were more difficult (especially for the disadvantaged children) because of the remoteness of the associations required to solve the problem, one item presented a matrix containing familiar objects whose actual size is very large -- a tree, a boat and a church building, while the other matrix contained pictures of objects small enough to be held in the hand -- a safety pin, a hair brush, and a key ring. Thus, the difficulty level of the Class Membership items varied from two items that were virtually impossible to solve by any of the children in the sample, to a large number of items that were readily answered correctly by even the youngest age groups.

A summary of performance on the Class Membership items is presented in Figure 2; a frequency distribution of raw scores is given in Figure 3. As expected, performance on these items improved with age. A small but stable difference between the scores of the advantaged and disadvantaged children is apparent. This difference is a reflection of performance on the more difficult items requiring remote associations and diluted by the uniformly high scores both groups achieved on the easier items mentioned previously.

The One-Way Classification items were more homogeneous in character; in every case it was the column or row membership of the vacant cell which determined the correct answer. Thus, in this set of items, all members of the same column, or row, were identical. In nine items, the columns of the matrix differed; in two items it was the rows that differed. Since all but one of these matrices were 3 x 2, they consisted of three rows of two members each and two columns of three members each.[4] The items did not require the child to abstract a common element of content, but, rather, demanded that he recognize the symmetry created by the identical nature of the column or row content. It should be noted that the One-Way Classification items followed directly after the Class Membership items, without any indication being given to the subject that the nature of the problem was being changed.

Performance on the One-Way Classification items among the disadvantaged children was appreciably less effective than on the Class Membership problems (see Figures 2 and 3). Scores declined still further, and to a marked degree, when the format of the item shifted from column to row membership as the defining property of the vacant cell. The two row membership items evoked almost universal failure among the disadvantaged children, even at the oldest age levels.

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4. One item involved a 2 x 2 matrix.

In addition, an item whose 2 x 3 matrix was made up of two columns of a mirror-image picture proved quite difficult. The two columns presented the picture of a girl's head; in the first column, she is obliquely facing the center of the matrix, in the cecond, she is also facing the center, but from the opposite direction. The four alternative pictures from which the children had to choose to fill the empty square included both versions of the girl's head. The direction the girl was facing was not a sufficiently striking cue to enable the children to differentiate the two columns and thus choose the correct picture. Those items which presented two columns of markedly different pictures were answered correctly most often. What is most striking is that the discrepancy in performance between the middle-class and disadvantaged children was substantially greater for the One-Way Classification items than for the Class Membership items. The performance of the advantaged kindergarten children on the Class Membership items most closely resembled that of the first-grade disadvantaged group, whereas the advantaged kindergarten's One-Way Classification scores exceeded those of the second-grade disadvantaged group.

The Two-Way Classification problems proved too difficult for even the oldest age groups. Only a handful of children, mostly, but not all, from the older, middle-class groups, were able to solve these problems. In Figure 2 we see that in both schools the children were equally inept at the kindergarten level, but whereas the disadvantaged children hardly show any improvement at succeeding ages, increasing numbers of advantaged children perform successfully at the older levels so that the performance curves for the two groups diverge markedly as age increases. It is interesting to note that the only Two-Way Classification item which evoked even moderate degrees of success in the whole group was one which formed a size gradient as one of its dimensions of variation. This gradient was more compelling than the qualitative differences in form which were used to differentiate the rows of the other problems.

Discussion

The results of this study indicate that when advantaged and disadvantaged children varying in age from five to eight years are given a set of classification tasks, relatively consistent differences between them are found. Differences between the groups on the Class Membership items were smaller than those found on the One-Way and Two-Way Classification problems.

While the Matrix Test was designed to assess the ability of young children to perform on four types of cognitive tasks, it is apparent that variation in the item content within each type of task substantially accounts for the total variance. It was not simply that the combining or unifying principle was less apparent in some problems than in others, but that in some items, a particular response alternative was so compelling that the child was distracted from the classification task. The data indicate that the Class Membership task is one that can be dealt with adequately by most young children of five or above, irrespective of their social-class background, provided that the exemplars of the class are easily labeled or their common element highly salient for young children. This means that when three objects belonging to the same class set are presented, a fourth member can usually be correctly chosen from among four alternatives. However, the basis for the appropriate grouping may be perceptual rather than conceptual, or the implicit naming of each of the objects in the matrix may set off a series of associations which provoke the correct choice of the fourth member of the matrix from among the alternatives. This may occur without a stable, established concept of class inclusion; it may not entail categorization.

Failure to classify correctly in a given problem may simply be attributable to the fact that the child has not yet learned the basis for that particular classification. Just as often, however, the basis is known to the child but it

is an infrequently used concept or attribute. In other words, it may be relatively low on the list of characteristics along which he usually orders objects. The data suggest that such less salient criteria are less likely to be used by disadvantaged children even though it is among their repertoire of means for ordering objects or events. It is probably true that disadvantaged children have learned fewer bases for categorizing events than have middle-class children, and that perhaps those that have been learned have not been learned as thoroughly, but it appears also to be true that they are less ready to use more remote, or less dominant bases for classifying events. The differences between the performance of the advantaged and disadvantaged children on the Class Membership items were relatively small, and almost entirely accountable in terms of items where the basis for classification was more remote. For example, the decline in their performance on the second Class Membership item, the color item, following successful performance on the first, form item, is understandable in terms of Smiley and Weir's (1966) findings regarding the dominance of the form dimension in a discrimination learning experiment. In the present study the disadvantaged children performed much more successfully under conditions in which prime associations to the stimuli in question corresponded to the correct answer. These most common, direct associations to the stimuli in the matrix were also evident in their incorrect answers to the difficult items. Thus it would appear that many of the children, more of them disadvantaged, were not classifying but associating.

A much greater gap between the disadvantaged and middle-class children was found in their performance on the One-Way Classification data. From these data, we may arrive at the seemingly trivial conclusion that grouping objects on the basis of their spatial arrangement is much more alien to disadvantaged children; or, it may be argued that the One-Way Classification problem provides a more

direct assessment of classification ability than does the Class Membership task. In order to recognize the pattern of row or column membership, there must be some implicit concept of a class or set which helps to differentiate the members of one array from the other. This reminds us that failure to classify may not only be the result of less articulated perception of a stimulus or the inability to apply less salient dimensions as criteria for classification, but may in fact represent an underdeveloped concept of class membership.

Despite their widespread failure on the One-Way Classification problems, it is important to note that most of the disadvantaged children responded to this task in a manner which appeared appropriate to them. They did not respond randomly, nor did they withdraw and refuse to respond at all. Analysis of their incorrect responses to the One-Way Classification items reveals that for the most part those who failed these problems chose the alternative which appeared most frequently in the matrix. Here, again, there is evidence that the disadvantaged children, in particular, responded very heavily in terms of frequency and recency. Their "wrong" responses were seldom irrelevant; rather, they were highly associational.

At the same time, some One-Way Classification problems were solved more often than others. When the two columns contained markedly distinctive figures, the One-Way Classification principle was more likely to be invoked. This pattern of responding was notably similar to that found in a previous study of conservation of number in five and six year olds (Zimiles, 1966). What appears to be characteristic of many children at this age level, particularly of the disadvantaged groups, is not that the relevant logical principle is unavailable to them, but rather that they fail to adhere systematically to the principle in question. The influence of a logical principle seems to be less potent and less pervasive, and is more likely to be supplanted by other factors and less likely

to be adopted as a guiding framework for dealing with succeeding problems. In the case of the Matrix Test, the children were prone to respond in terms of a very compelling relationship between one response alternative and a single member of the matrix.

These observations are in accord with those made by several other investigators. Sigel (1966), in a comparison of the sorting behavior of middle-class and disadvantaged children, has reported that young disadvantaged children, when they were able to sort, gave a higher frequency of relational-contextual responses, that is, they sorted items based on functional or thematic relations -- on the basis of associations between items that were based on their own experience. Middle-class children, on the other hand, more often sorted on the basis of descriptive characteristics. Jensen (1968), in a recent analysis of the findings of comparative studies of advantaged and disadvantaged children, in which he examined those areas in which the two groups perform quite similarly and those where they are sharply differentiated, has concluded that disadvantaged children perform well on associative tasks, but fall off badly on tasks requiring more complex mental processes. Marion Blank (1968) has recently described a tutorial program she devised which is based on the premise that the major cognitive deficit of the disadvantaged child is in the area of abstract thinking. Her program is therefore geared toward fostering the ability to categorize, engage in cause-effect reasoning, and other related reasoning behaviors.

If this tentative conclusion regarding the deficit in abstract thinking is correct, it is understandable why some advocates of compensatory education for disadvantaged children have reverted to traditional methods of rote learning and drill in teaching these children. These methods are likely to bring tangible results with children who are prepared to respond associatively; they can learn to repeat what they hear over and over again. However, such an

educational program is likely to bypass completely what appears to be a more basic need of the disadvantaged child -- that of achieving a level of organization and integration which supports a problem-solving attitude, a mode of functioning that is curious, reflective and analytic. How such cognitive growth can be accelerated, and whether, indeed, it can be materially accelerated, is a matter yet to be determined.

The data of this study once more give emphasis to the multi-faceted nature of inferential thinking and logical reasoning, a fact which complicates the measurement of these behaviors. Failure to solve the Matrix Test problems may be attributable to a large number of factors: an inability to make appropriate perceptual discriminations, a meagerness of informational and conceptual content upon which to base the labeling and ordering of given objects or events, an inability to use bases for classification which have been learned but are infrequently used, a lack of clarity regarding the notion of class membership, or a relative absence of self-criticism in responding to problem situations. It seems reasonable to believe, however, that cognitive development proceeds in terms of levels of organization which embody all these interrelated attributes.

It may be speculated that the essential antecedents of such development are probably a stable, predictable environment where principal figures explain their behavior and important events occur with regularity, one in which the child is encouraged to behave as an active participant rather than as a resigned victim. The child's feeling of self-worth and his sense of trust in others are probably important determinants of the standards and sights he sets for himself and the manner in which he differentiates the environment and orders events. How these factors, if they do in fact relate to the main antecedents, can become operative in the classroom, and the most realistic time perspective for producing the desired changes, are still unresolved issues. Whatever the

nature of the antecedents, the data emphasize how gradual is the growth in this area of functioning. There was wide variability of performance within each age level, and only moderate change with age. Therefore, it would seem unrealistic to expect short-term interventions to produce dramatic shifts in behavior.

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Figure 1

Per Cent of Correct Responses to Items #1 (form) and #2 (color) of the Class Membership Set as a Function of Age and Social Class

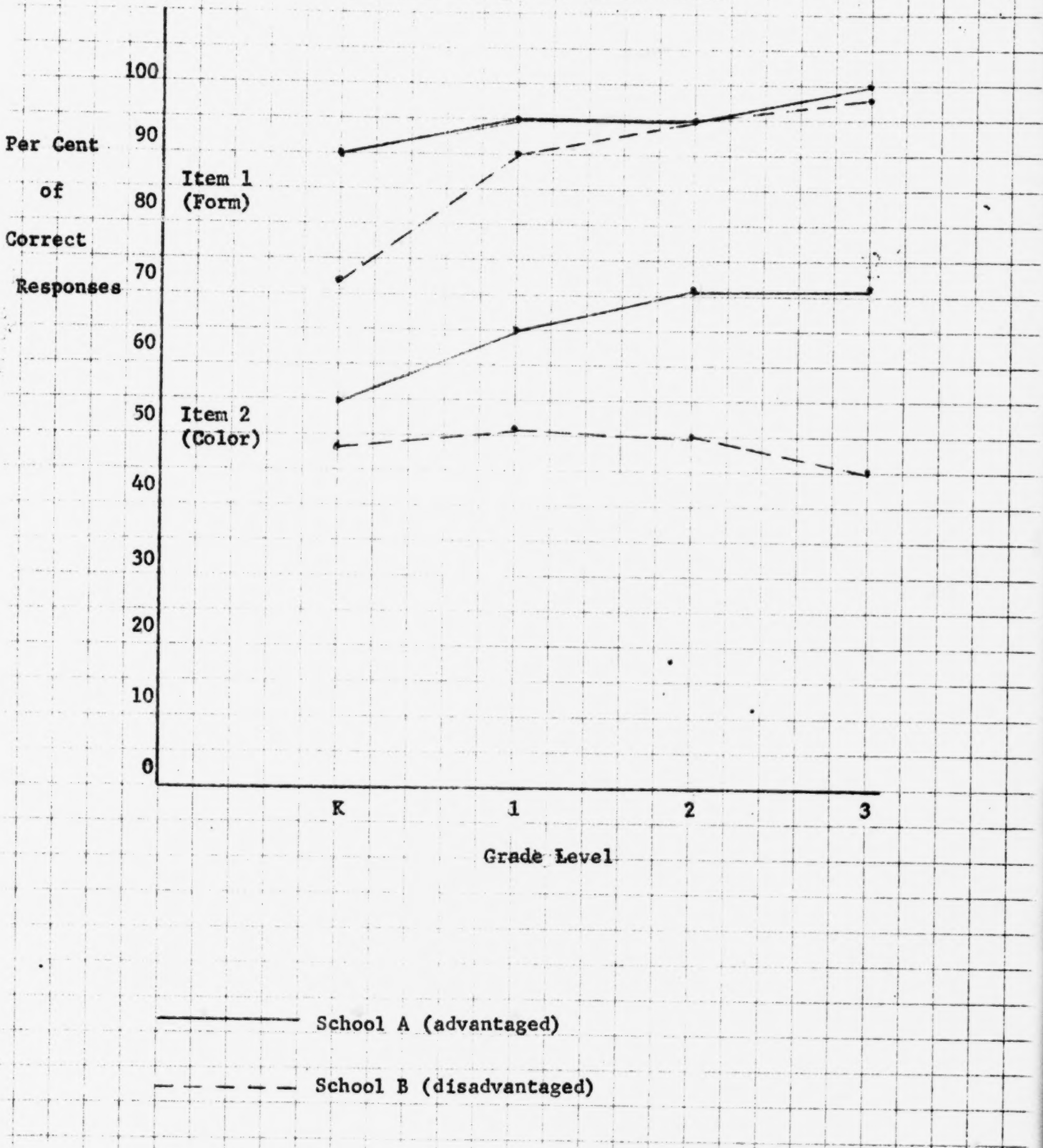


Figure 2

Per Cent of Items Answered Correctly as a Function of Age and Social Class Background

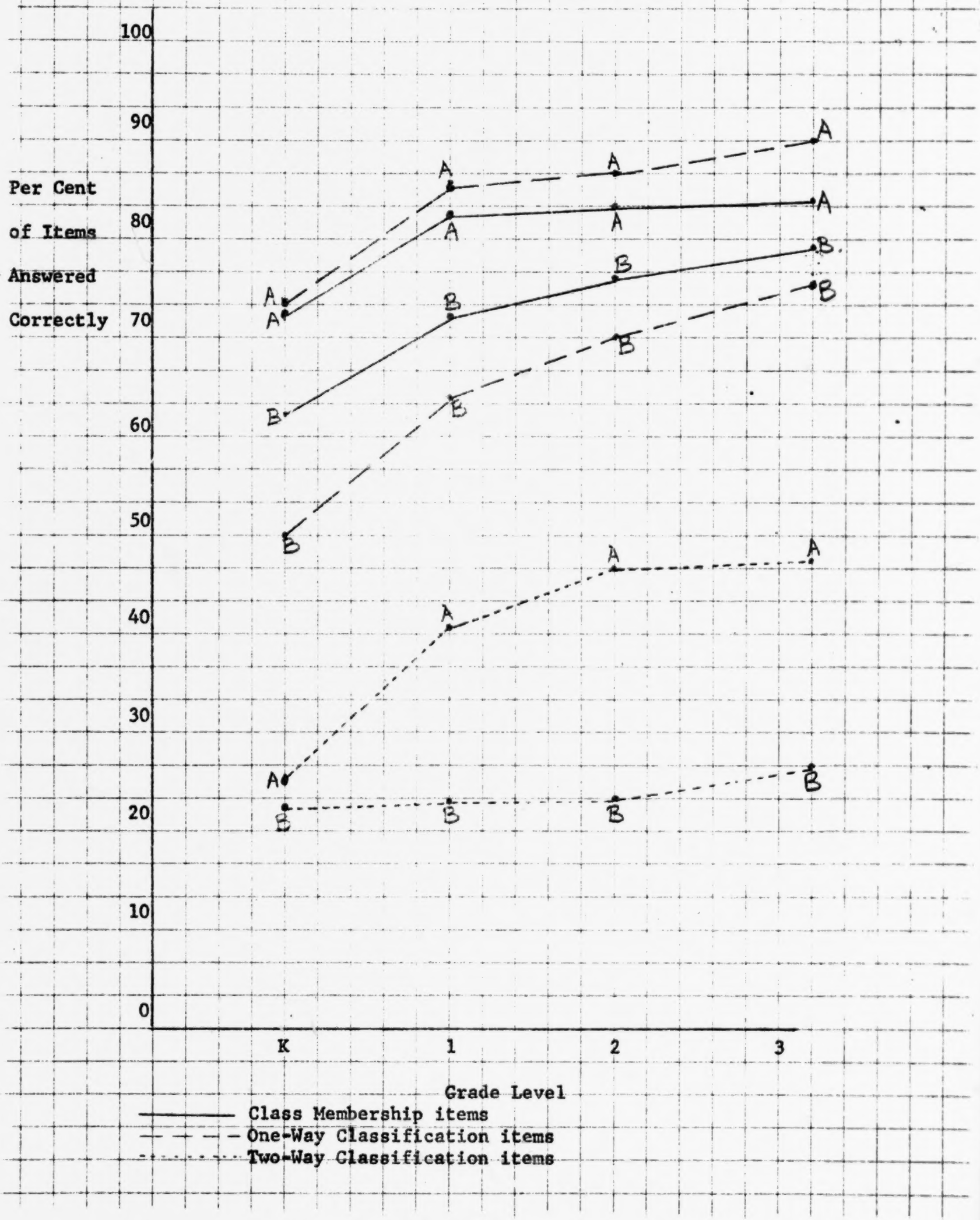
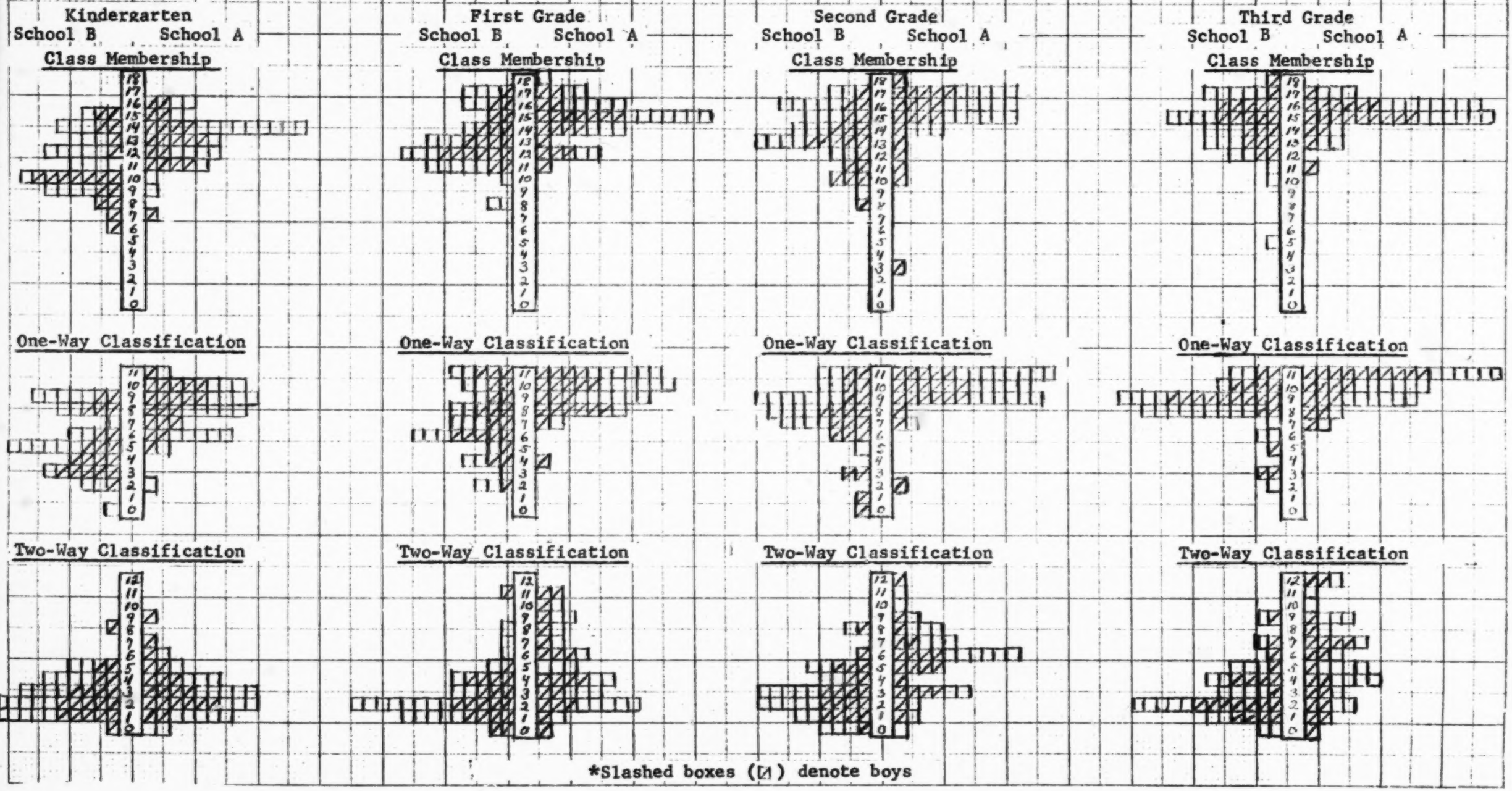


Figure 3

Frequency Distributions for Total Scores on Each of Three Item Clusters -- Class Membership, One-Way Classification, Two-Way Classification -- According to Grade, School and Sex*



*Slashed boxes (▨) denote boys